AEROCAPTURE TECHNOLOGY DEVELOPMENT FOR PLANETARY SCIENCE – UPDATE

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Introduction: Within NASA's Science Mission Directorate is a technology program dedicated to improving the cost, mass, and trip time of future scientific missions throughout the Solar System. The In-Space Propulsion Technology (ISPT) Program, established in 2001, is charged with advancing propulsion systems used in space from Technology Readiness Level (TRL) 3 to TRL6, and with planning activities leading to flight readiness. The program's content has changed considerably since inception, as the program has refocused its priorities. One of the technologies that has remained in the ISPT portfolio through these changes is Aerocapture. Aerocapture is the use of a planetary body's atmosphere to slow a vehicle from hyperbolic velocity to a low-energy orbit suitable for science. Prospective use of this technology has repeatedly shown huge mass savings for missions of interest in planetary exploration, at Titan, Neptune, Venus, and Mars. With launch vehicle costs rising, these savings could be the key to mission viability. This paper provides an update on the current state of the Aerocapture technology development effort, summarizes some recent key findings, and highlights hardware developments that are ready for application to Aerocapture vehicles and entry probes alike.

Description of Investments: The Aerocapture technology area within the ISPT program has utilized the expertise around NASA to perform Phase A-level studies of future missions, to identify technology gaps that need to be filled to achieve flight readiness. A 2002 study of the Titan Explorer mission concept showed that the combination of Aerocapture and a Solar Electric Propulsion system could deliver a lander and orbiter to Titan in half the time and on a smaller, less expensive launch vehicle, compared to a mission using chemical propulsion for the interplanetary injection and orbit insertion. The study also identified no component technology breakthroughs necessary to implement Aerocapture on such a mission. Similar studies of Aerocapture applications at Neptune, Venus, and Mars were studied in 2003 through 2005. All showed significant performance improvements for the missions studied. Findings from these studies were used to guide the technology development tasks originally solicited in a 2002 NASA ROSS Research Announcement. The tasks are now in their final year and have provided numerous improvements in modeling and hardware, for use in proposals or new mission starts.

Major Accomplishments: Since validation of the Aerocapture maneuver requires a space flight, ground developments have focused on modeling and environment prediction, materials, and sensors. Lockheed Martin has designed and built a 2-meter Carbon-Carbon aeroshell "hot structure." The article utilizes co-cured stiffening ribs and advanced insulation to achieve large scale, and up to a 40% reduction in areal density over the Genesis probe construction. This concept would be an efficient solution for probes that experience heat rates near 800-1000 W/cm^2, such as at Venus and Earth. Applied Research Associates has extensively tested a family of efficient ablative TPS materials that provide solutions for a range of heating conditions. These materials are being applied to high-temperature structures built by ATK Space Systems, led by Langley Research Center. One-meter aeroshells will be thermally tested to validate construction and demonstrate higher bondline temperatures, which can lead to mass savings of up to 30% over traditional heatshields. Ames Research Center has developed aeroshell instrumentation that could measure environmental conditions and material performance during atmospheric entry. Instruments to measure TPS recession, heat flux, and catalycity could be combined with traditional sensors to provide a "plug-and-play" system for minimal mass and power, that would acquire flight data for model improvement and risk reduction on future missions. Improved atmospheric and aerothermodynamic models have also been a major focus of the program.

Next Steps: Aerocapture is one of five technologies in competition for a flight validation opportunity through the New Millennium Program. If selected, a fully autonomous vehicle will perform an Aerocapture at Earth in 2010, and flight data will be used to validate the guidance system and the TPS material for science mission infusion.